Special Studies Summary

http://www.epa.gov/oar/aqtrnd03/chapter6.pdf

Summary of Exploratory Analyses

This chapter summarizes several recent papers describing analyses conducted on various policy-relevant topics. Two of the papers analyze aspects of particulate matter. The first covers an event in which particulate matter was transported from Asia and its effect on parts of the United States. The second discusses speciated $PM_{2.5}$ in urban and rural areas. Trends in CO in localized areas are analyzed in a third article, providing a better understanding of oxyfuel programs. Current-year ozone levels are compared to historical trends in a fourth paper. New tools are discussed in two additional papers. One tool is the coefficient of perfect agreement, or CPA, which is derived to assist in characterizing the spatial variation of pollutants. The final paper discusses a new reporting and display tool that could be used to present air quality information in an innovative way. The papers are presented in their entirety in the Special Studies section at the end of this report.

Impact of April 2001 Asian Dust Event on PM Concentrations in the United States

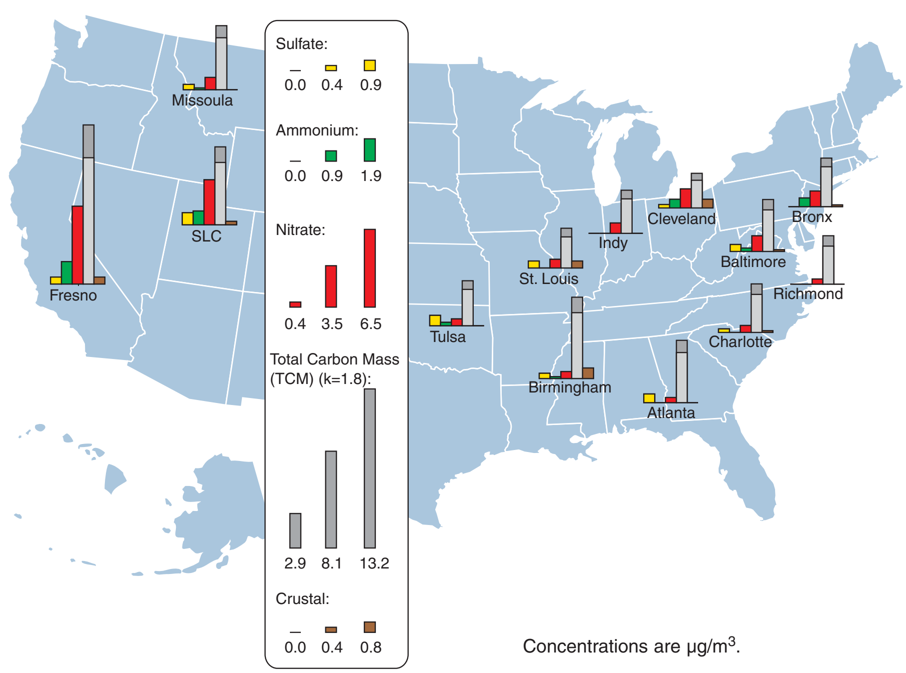
Jim Szykman, David Mintz, Jack Creilson, Michelle Wayland

On April 6, 2001, the combination of strong surface winds and an intense area of low pressure over the Gobi Desert produced a large dust cloud that was lofted into the free troposphere and transported east. The dust cloud, captured and tracked by satellite imagery, made its way across the Pacific Ocean and reached the United States on April 12 and 13. Examination of ridges and troughs, rising or sinking air, and trajectories showing origins and paths of air masses were all used to understand how and when the dust cloud affected measurements of PM in the United States.

The position of the dust cloud and vertical movement of air was found to determine which regions experienced elevated "soil" PM concentrations. U.S. regions from Utah to Maine were impacted. Specific regions impacted were the West (on April 16th), the Southeast (on April 19th), and the Mid-Atlantic/Northeast (on April 22nd).

Quantities of soil-related particles attributable to the dust storm were calculated using historical trends to develop a baseline of typical April soil concentrations in particulate

Figure 6-1. Urban $PM_{2.5}$ increments.



Concentrations are µg/m³.

matter. Table 6-1 shows the quantities attributable to the dust storm by region. This dust event is the first time that East Coast soil particulate matter peaks have been associated with dust transport from Asia. Peak concentrations were composed of fine fraction (detected as $PM_{2.5}$) in some locations and coarse fraction (detected as PM_{10}) at other locations. Composition of the dust-storm-related particles was examined using percentages of potassium, calcium, and silicon as indicators of whether the detected dust was Asian in origin. These chemical speciation data showed that the Asian dust contributed, on average, 3.1 to 7.4 $\mu g/m^3$ to the total $PM_{2.5}$ mass concentrations during the period studied.

Potential health impacts of the dust were also examined. On the dates on which the dust cloud was crossing the United States, there were nine areas with an EPA Air Quality Index (AQI) value above 100 for PM_{10} or $PM_{2.5}$, indicating that the air quality posed a health risk to sensitive populations such as children and the elderly. Unfortunately, there are no speciation data in these areas for estimating Asian dust contributions. Further review and, in some cases, additional data would be needed to determine whether the Asian dust event contributed to these levels.

Table 6-1. Estimated $PM_{2.5}$ Concentrations Attributable to Asian Dust Cloud

Date	Number of Sites	Site Locations	Median Typical April Soil Concentration ($\mu g/m^3$)	Median Asian Dust Contribution ($\mu g/m^3$)	Maximum Asian Dust Contribution ($\mu g/m^3$)
4/16/01	43	West	0.7	7.4	21.2
4/19/01	19	Midwest and Southeast	0.5	3.6	12.9
4/22/01	16	Mid-Atlantic and Northeast	0.4	3.1	7.4

Chemical Speciation of $PM_{2.5}$ in Rural and Urban Areas

Venkatesh Rao, Neil Frank, Alan Rush, and Fred Dimmick

Existing ambient air quality monitoring data from the predominantly urban Speciation Trends Network (STN) and the predominantly rural Interagency Monitoring of Protected Visual Environment (IMPROVE) network were analyzed to identify first-order approximations of local and regional contributions to urban $PM_{2.5}$ concentrations from March 2001 to February 2002. Urban sites were paired with matched rural sites to calculate the "urban increment" of $PM_{2.5}$ mass and increment of individual species. Data from the two monitoring networks were selected and adjusted to create comparable datasets. This work addressed the problem that often half or more of $PM_{2.5}$ is composed of secondarily formed species, thus hiding their point of origin.

Figure 6-1 shows the urban increments by components. On average, the urban excess for the site combinations investigated was found to be 8 $\mu g/m^3$. Carbonaceous mass was found to be the major contributor to urban excess at all sites studied. Such an amount of $PM_{2.5}$ implies that programs are likely needed to address urban sources of $PM_{2.5}$.

Carbonaceous mass appears to be attributed to local emissions, with mobile sources as a possible major contributor. Nitrates are prevalent in the urban excess estimates of the North and West, but not in the East. However, more work is needed to assess the compatibility of nitrate measurements and monitoring methods between networks. Some locations show a sizeable urban excess of crustal materials, some of which may be attributed to industrial sources.

Trends in Monitored Concentrations of Carbon Monoxide

Jo Ellen Brandmeyer, Peter Frechtel, Margaret Z. Byron, Joe Elkins, James Hemby, Venkatesh Rao

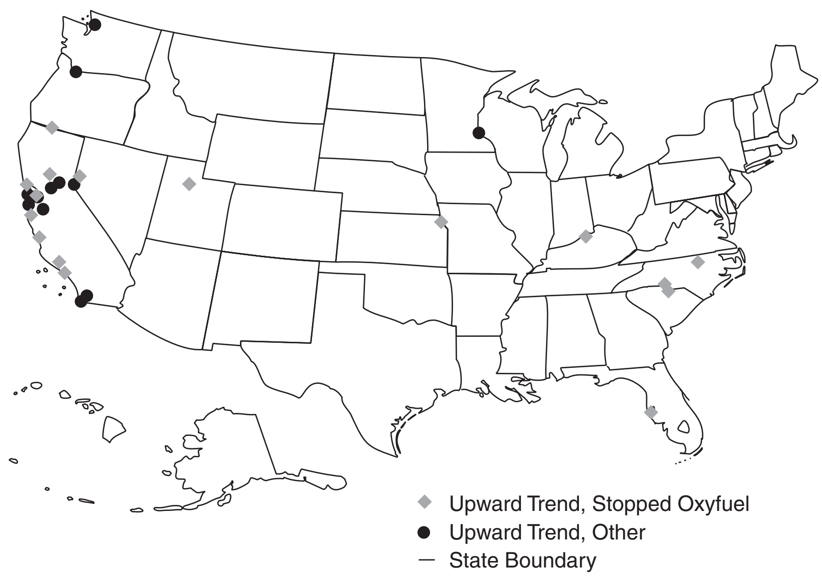
In 1999, numerous metropolitan areas instituted oxygenated gasoline (oxyfuel) programs during winter months to reduce CO emissions from motor vehicles. Some have since discontinued these requirements. This paper demonstrates a screening method for determining CO trends at specific monitoring stations. By contrast, we often examine trends for regions based on metropolitan statistical areas (MSAs). By eliminating averaging across MSAs, this study identified trends in more localized areas. Uncovering localized trends is important when one part of an MSA experiences rapid population growth accompanied by a rapid growth in vehicular emissions.

This study used data from EPA's Air Quality System (AQS), which contains air quality data from the air quality monitoring stations. Stations with at least 8 years of relevant data during the period 1990 through 2000 were screened for either an upward linear trend or upward inflection. The second maximum nonoverlapping 8-hour average of CO for each monitor over the 11-year period was used.

Because no single test will necessarily detect trends at all relevant sites, three separate statistical tests were applied to data from each station: Theil test, first-order linear regression, and quadratic (second-order) linear regression. The three tests were used together to discern patterns in the data. Of the 433 sites analyzed, 34 showed a statistically significant overall upward trend or statistically significant upward curvature. Figure 6-2 shows locations of these sites and whether they have discontinued their oxyfuel programs. Of the sites listing dates ending the oxyfuel program, all either are located in a federal reformulated gasoline area or have an oxyfuel requirement in their contingency plan.

This analysis method can be used to screen for sites with increasing CO concentrations. The identified sites should then be examined further to determine the magnitude of the concentrations as compared to the existing standard. Because both vehicle miles traveled and the vehicle mix in fleets are changing with time, the authors recommend repeating this analysis annually to determine sites that warrant further analysis.

Figure 6-2. Monitoring stations showing upward CO trends.



Cumulative Ozone Exceedances—A Measure of Current Year Ozone Levels Compared to Historical Trends

Dennis Doll, Terence Fitz-Simons

Policy makers at the state and federal level are often asked how the current year's ozone season compares to previous years. In order to address that question, the authors used data measured in the Air Quality System network of monitoring stations maintained by EPA's Office of Air Quality Planning and Standards. We addressed data from the network of monitors assigned to cities for which the air quality index (AQI) is forecasted during the ozone season (i.e., April-October), known as the "USA Today list of cities." Data from 2002 (the most recent year) were compared to a 5-year historical average in these cities and the regions in which they are located. Based on this comparison, policy makers can qualitatively assess the severity of the most recent year's ozone measurements with historical year measurements.

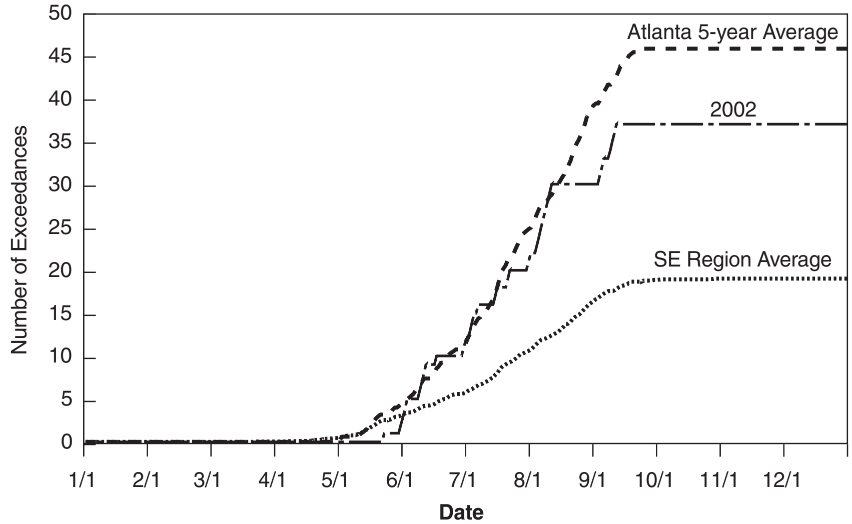
To construct the measurements, the authors used AQS data to analyze the number of days ozone measurements exceeded the 8-hour NAAQS for ozone (>0.085 ppm). This indicates that air quality falls into the category "Unhealthy for Sensitive Groups." For the given set of monitors assigned to a city, if one or more monitors measured an 8-hour ozone level >0.085 ppm, the researchers recorded an exceedance for the day. This procedure was repeated for each day of the year for the set of monitors assigned to each city. In this way researchers counted the number of days exceedances were measured in a given city in 2002. For the historical 5-year period 1997 to 2001, the average number of the cumulative count of days was obtained over the 5-year period for each set of monitors assigned to each city to yield a 5-year trend.

We then divided the subject cities into geographic regions and examined a 5-year cumulative regional average as well as city-based averages. This measure helps illustrate differences among and within regions.

Analysis of the southeast region showed that, in 2002, ozone trends in Atlanta and Charlotte were similar to 5-year southeast regional trends, while in Memphis, Nashville, and New Orleans, the number of exceedances was lower than the 5-year regional trends. Figure 6-3 shows the comparison of Atlanta and regional trends. In contrast, for most of the cities analyzed in this study in the northeast region, the 2002 data revealed a lower trend than the 5-year average through approximately early July, then a higher trend than the 5-year average from mid-July into mid-September.

Cities analyzed in the midwest region analysis showed seasonal variation for 2002 compared with the 5-year average. For Chicago, Cleveland, Cincinnati, Columbus, Pittsburgh, Indianapolis, Detroit, and St. Louis, the 2002 data trends were lower than the 5-year average through approximately mid- to late June, then were progressively higher than the 5-year average from late June onward. Midwest cities outside the core midwest region (e.g., Kansas City and Minneapolis) showed 2002 data trends similar to or lower than the 5-year average data.

Figure 6-3. Cumulative exceedances—5-year average (97–01) (Atlanta) compared to 2002 data and southeast region average.



Characterization of National Spatial Variation

Terence Fitz-Simons

Spatial variability is an important quality of air pollutants for many areas of policy within EPA. Monitoring regulations depend heavily on knowledge of spatial variability. Control strategies, "action day" programs, and public information programs also rely on this knowledge. This paper explores a new way to examine spatial variability on a national scale that addresses the limitations of existing spatial variability methods.

Traditional Spatial Methods and Their Limitations

Often spatial variability is examined by creating a map showing ranges of pollutant levels by county. Such a map shows which counties have higher pollutant values, but does not allow easy visualization of how close adjoining counties are to others. Some analysts enhance spatial maps with an estimated surface of pollutant levels using a spatial interpolation technique known as kriging. Kriging removes the blank areas on a map, making it somewhat easier to see how pollutants vary over space; however, because the surface itself is smoothed by the process, kriging actually hides some of the spatial variation.

Kriging relies on variograms, which represent the statistical variance of the difference between two data points on a map as it relates to the distance between the two points on the map. The variogram, in turn, relies on the variance, which is a measure of the spread of a distribution or data representing measurement differences between two locations paired by time. The authors use a scatterplot of particulate matter ($PM_{2.5}$) data to examine how effectively such kriged maps represent the actual relationship between locations paired by time. The scatterplot shown in Figure 6-4 makes clear that there is no simple relationship between the variance of the difference and distance. This brings into question the assumption used in kriging that the variance of the difference over distance can be described by a line.

The authors next investigated correlation over distance, using $PM_{2.5}$ to calculate the correlation of daily $PM_{2.5}$ values between two sites. Latitude and longitude were used to calculate the distance between two sites, producing a correlation and a distance for each pair of sites. Based on that information, scatterplots were generated that further question the simplicity of the variogram used in kriging.

Coefficient of Perfect Agreement Method

The coefficient of perfect agreement (CPA) method addresses the problems raised in the examination of kriging. CPA provides a measure of agreement with many of the characteristics of the correlation coefficient, thus allowing examination of the agreement between pollutant values over distance.

The classical correlation coefficient is a measure of how well paired values track each other. The value 0 (zero) means they do not track each other at all, while a value of 1 means they track each other perfectly. The correlation coefficient is defined as:

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\frac{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}{n}}$$

The authors discuss several issues involved in constructing a CPA, including sample size, and managing units conversion so that the resulting CPA is unitless. Within those restrictions, the authors apply the CPA to construct a new scatterplot of $PM_{2.5}$. Figure 6-5 shows that the denser part of the distribution dips quickly and falls off gradually. This is a different trend than that found in the earlier scatterplot (shown in Figure 6-4) based on variance of difference vs. distance.

This scatterplot gives a national picture of the spatial variation of $PM_{2.5}$. The mean CPA starts off at around 0.6 and falls off rapidly out to about 150 km, then falls off gradually to about 0.2 at 500 km. Quantitatively, interpretation of this coefficient is difficult, but it is useful in comparisons with other pollutants. To compare pollutants, the authors display the scatterplot as a box and whisker plot. Pollutants can then be compared by joining the means by a line for several pollutants.

Such comparisons between pollutants could be used to guide policy. For example, daily values of $PM_{2.5}$, daily values of PM_{10}, hourly values of CO (carbon monoxide), and hourly values of ozone were used to produce Figure 6-6. The plot of $PM_{2.5}$ has a mean CPA that is above ozone for most of the distances out to at least 450 km. This might suggest

Figure 6-4. Variance of the difference vs. distance.

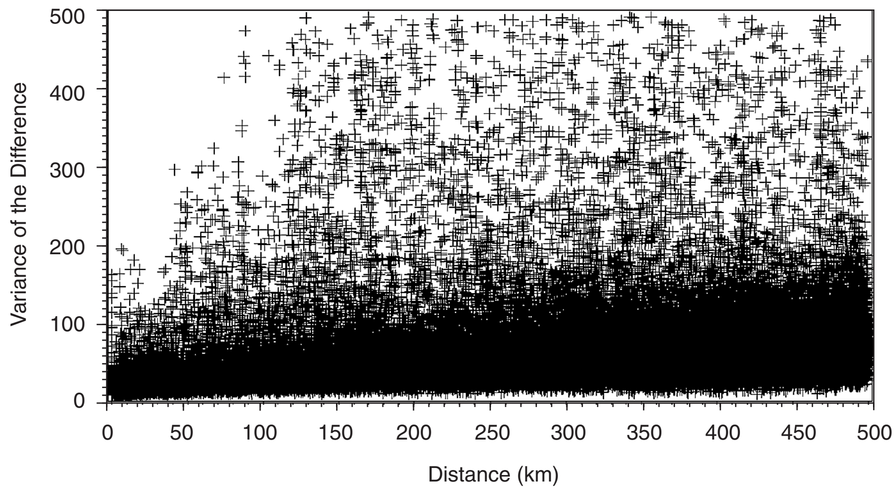


Figure 6-5. CPA vs. distance (km).

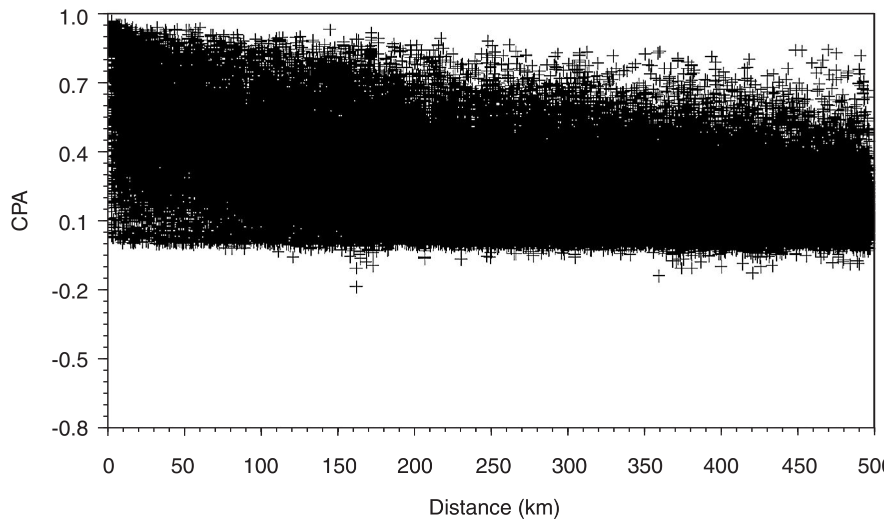
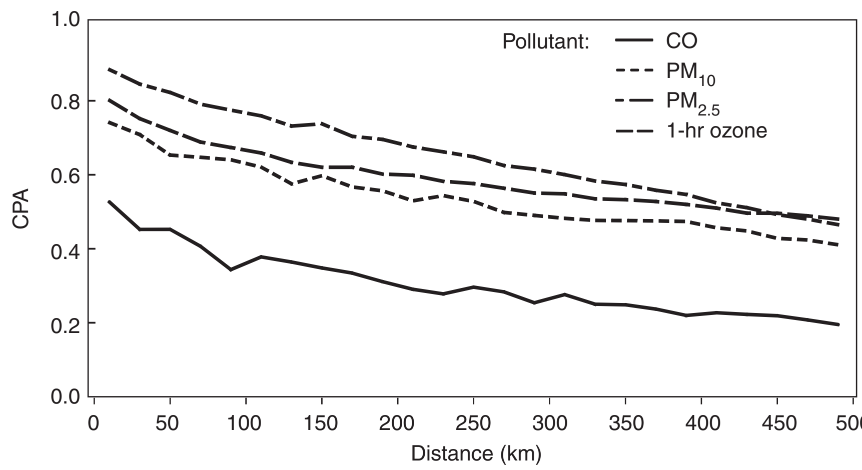


Figure 6-6. Comparison of mean CPA vs. distance (km).



that, if a regional control strategy is being pursued for the ozone problem in the United States, a regional strategy also makes sense for $PM_{2.5}$.

Development of a New Reporting Technology for Air Quality

Prepared by RTI International for the Office of Air Quality Planning and Standards

This display technique would provide the general public with a new tool to review air quality in MSAs around the United States. The primary function of the display would be to present location- and pollutant-specific air quality data in a graphical format that allows for easy interpretation of air quality data for MSAs. The display would not provide new or additional air quality data; rather, it would present existing data in a new format. The graphical display of data would improve the public's access to air quality information and enhance their ability to use this information in a meaningful way. Potential capabilities that may be added include a Web-based application that would allow users to sort and query information to generate customized reports, as well as visibility and multiyear components.

EPA recognizes that there are limitations to this new display technique and is continuing to assess the usefulness of such a reporting method as well as additional capabilities that might be added. Developing a simple metric for displaying air quality data on an urban basis across the nation is a difficult and challenging endeavor. However, EPA feels that this information is useful and informative to the public, especially to those who have potential health concerns related to poor air quality. A graphical display that is easily understood is essential to communicating this information, and EPA will continue to refine the display to ensure that it meets this objective based on comments and input from the air quality community and potential users.